Climate Change and Its Impacts on plant Phenology in China for the Last 40 Years

Zheng Jingyun

Institute of Geographic Sciences and Natural Resources Research, CAS

Content

1. Data

2. Phenophase variation

3. Climate variation

4. Relationship between natural phenophase and climate variations

5. Summary

1. Data

Task D: Effect and impact of climate change on human and natural systems

- To examine the regional scale effects of climate change and climate variability on natural resources (water and unmanaged ecosystems) and on agriculture, grazing and forestry.
- To apply process models (for crop yields, soil erosion, runoff, stream flow and changes in bio-geography) to selected regions of China and the U. S. using validated data sets on climate, soils and management practices.
- ……
- **How will natural and human systems respond to the changes?**

Phenology is regarded as one of the synthetical indicator for the environmental change, particularly for the climate change based on Hopkins Law

In recently, the climate change impact on phenology now is in “hotspot”, and many case studies are adopted in the IPCC Report, such as:

Bradley N L, et al. Phenological changes reflect climate change in Wisconsin. Proceeding of the National Academy of Science, USA, 1999, 96: 9701

Abu-Asab M S, et al. Earlier plant flowering in spring as a response to global warming in the Washington, DC, area. Biodiversity and Conservation, 2001, 10: 597

…….

1. Data

- Phenophase: **Chinese Phenological Observation Network**

  Duration: 1963~1996

  Spatial Coverage: 26 stations,

  (cover most of China, particular in the eastern)

  Phenophases selected: 17, such as:

  ***Salix babylonica* L. leaf unfolding, flowering;**

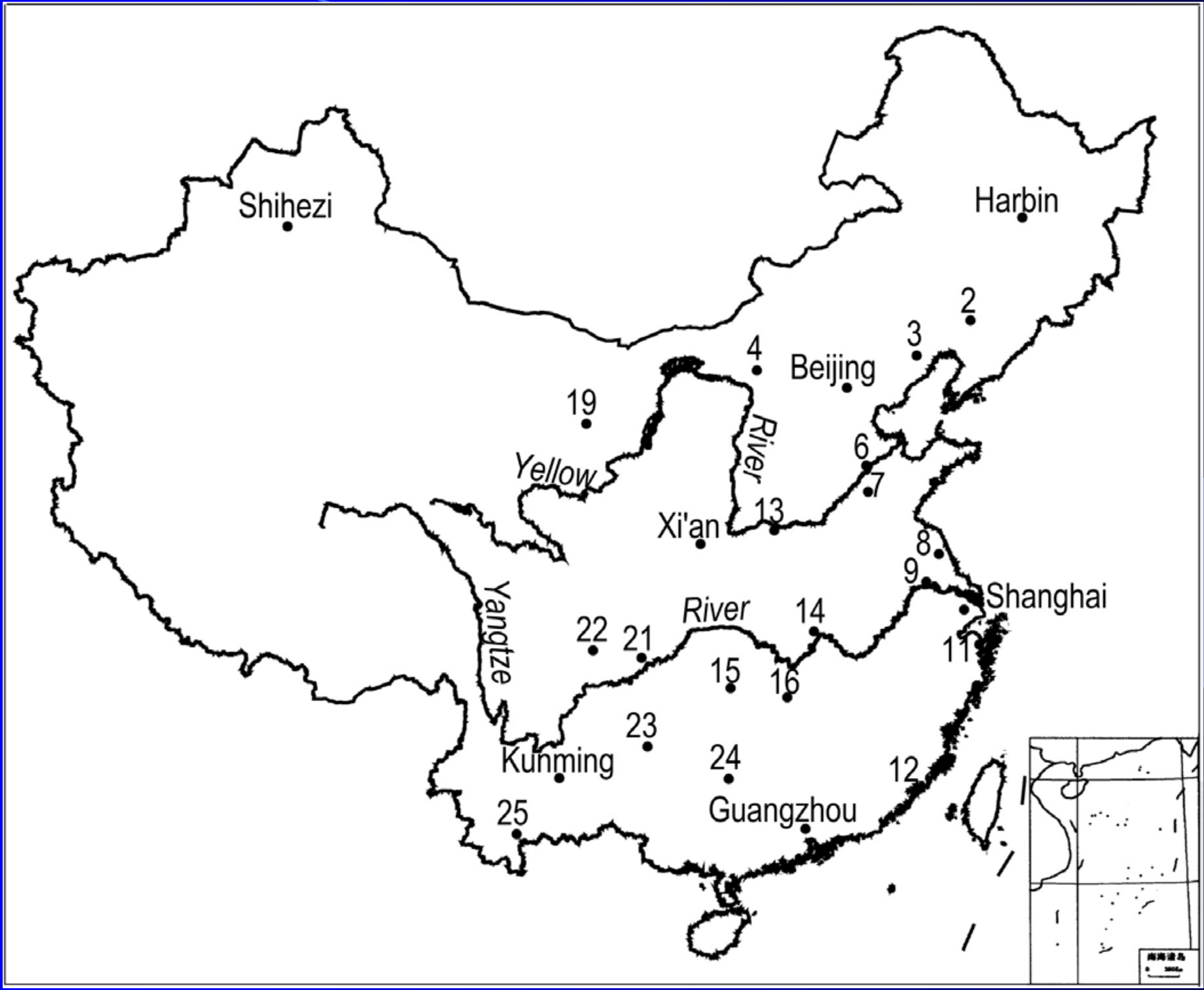
  ***Prunus persica* L. Batsch flowering;**

  ***Prunus davidiana* Franch flowering; etc.**

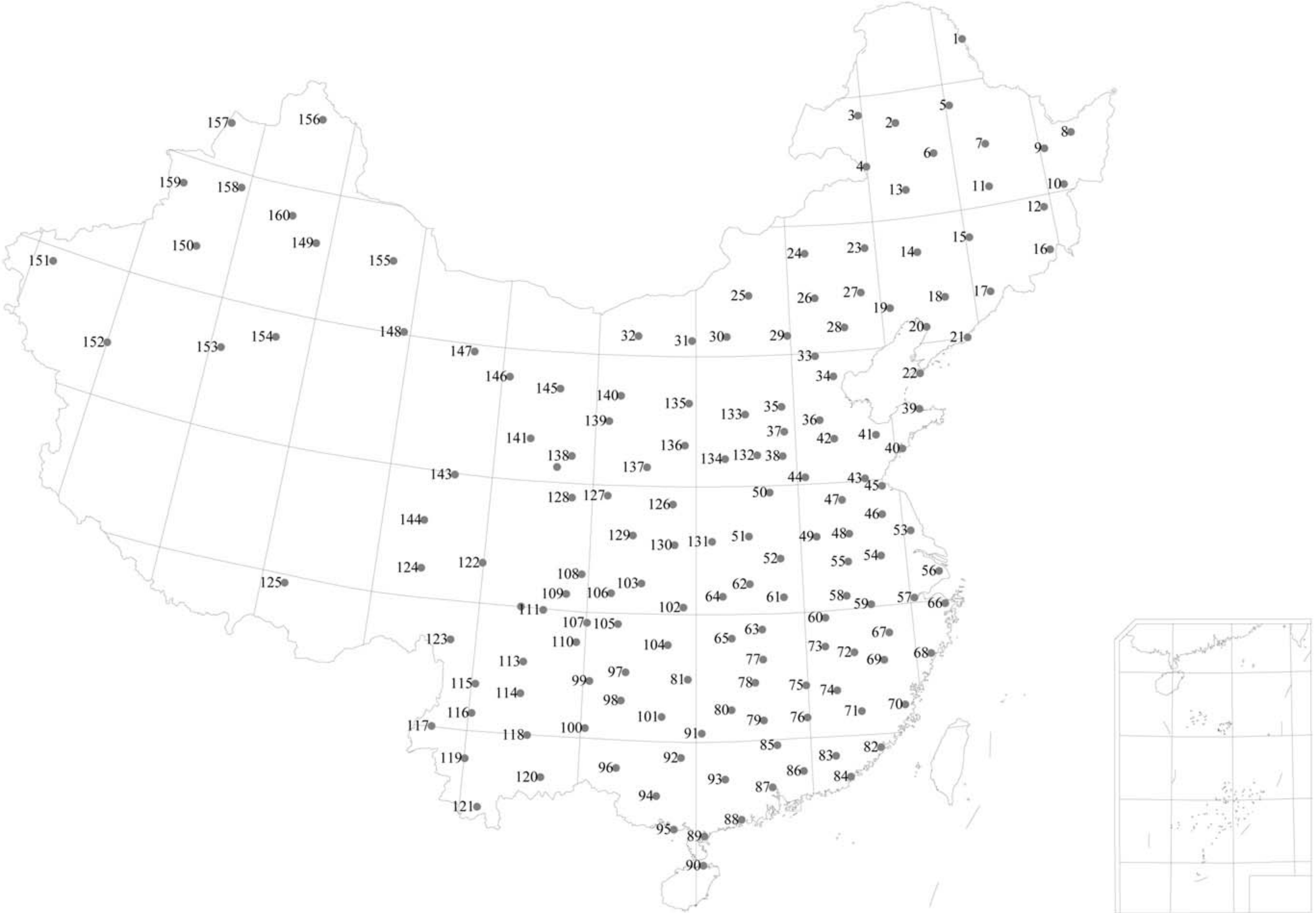
- Climate: Daily **temperature and Precipitation**

  Spatial Coverage: 160 stations

  Duration:1961~2000



The location of selected stations from CPON used in this study



The location of stations for daily climate data used in this study

Data

For phenophase data

☞ Set up the individual phenophase series for every station

☞ Calculate the mean value of the difference of pheno-date in spring in every station between 1963~1980 and 1981~1996;

☞ Identify the difference of spring temperature in every station between 1963~1980 and 1981~1996;

Data

For climate data

☞ Identify the duration of growth season, non-growth season, and transition season based on the mean daily temperature in the period of 1961~1990 (normal condition)

(a) growth season: continuous days of $T_d \geqslant 10$℃

(b) non-growth season: continuous days of $T_d \leqslant 0$℃

(c) transition season I: continuous days of $0℃ \leqslant T_d \leqslant 10℃$

(d) transition season II: continuous days of $10℃ \geqslant T_d \geqslant 0℃$

Data

☞Set up the temperature anomaly and precipitation anomaly percentage series for the four seasons (growth season, non-growth season, transition season I and transition season II) for individual station during the period of 1961~2000 based on the referee period of 1961~1990.

☞Then, setup the temperature anomaly and precipitation anomaly percentage series for the four seasons for the whole China (mean of all station) during the period of 1961~2000.

☞Identify the difference of mean temperature between 1961~1980 and 1981~2000 for four seasons in every station.

2. Phenophase variation

2. Phenophase variation:

Individual station

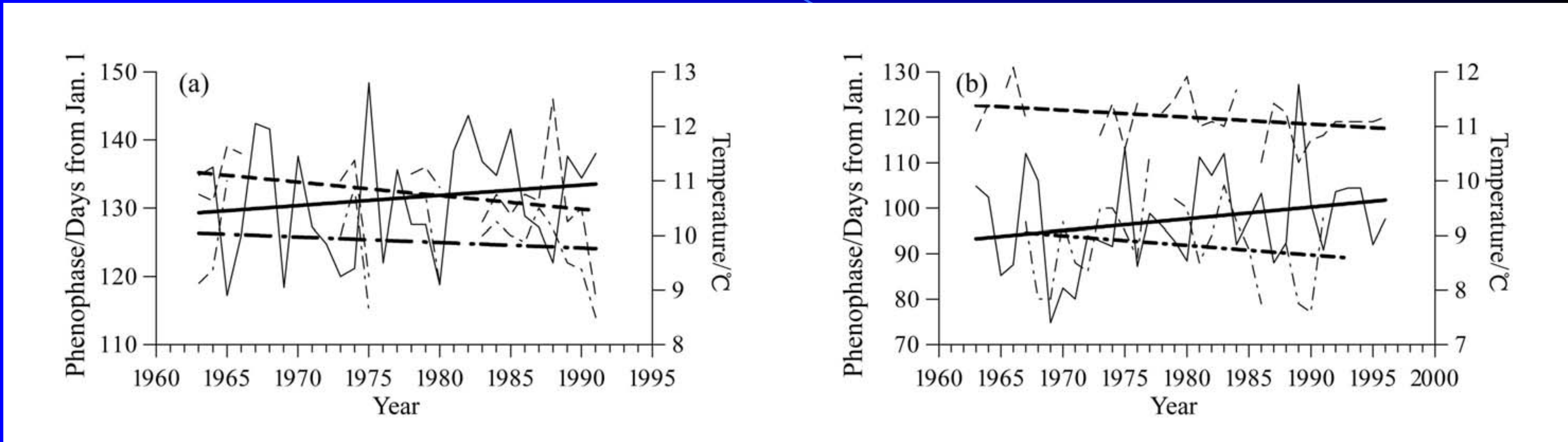
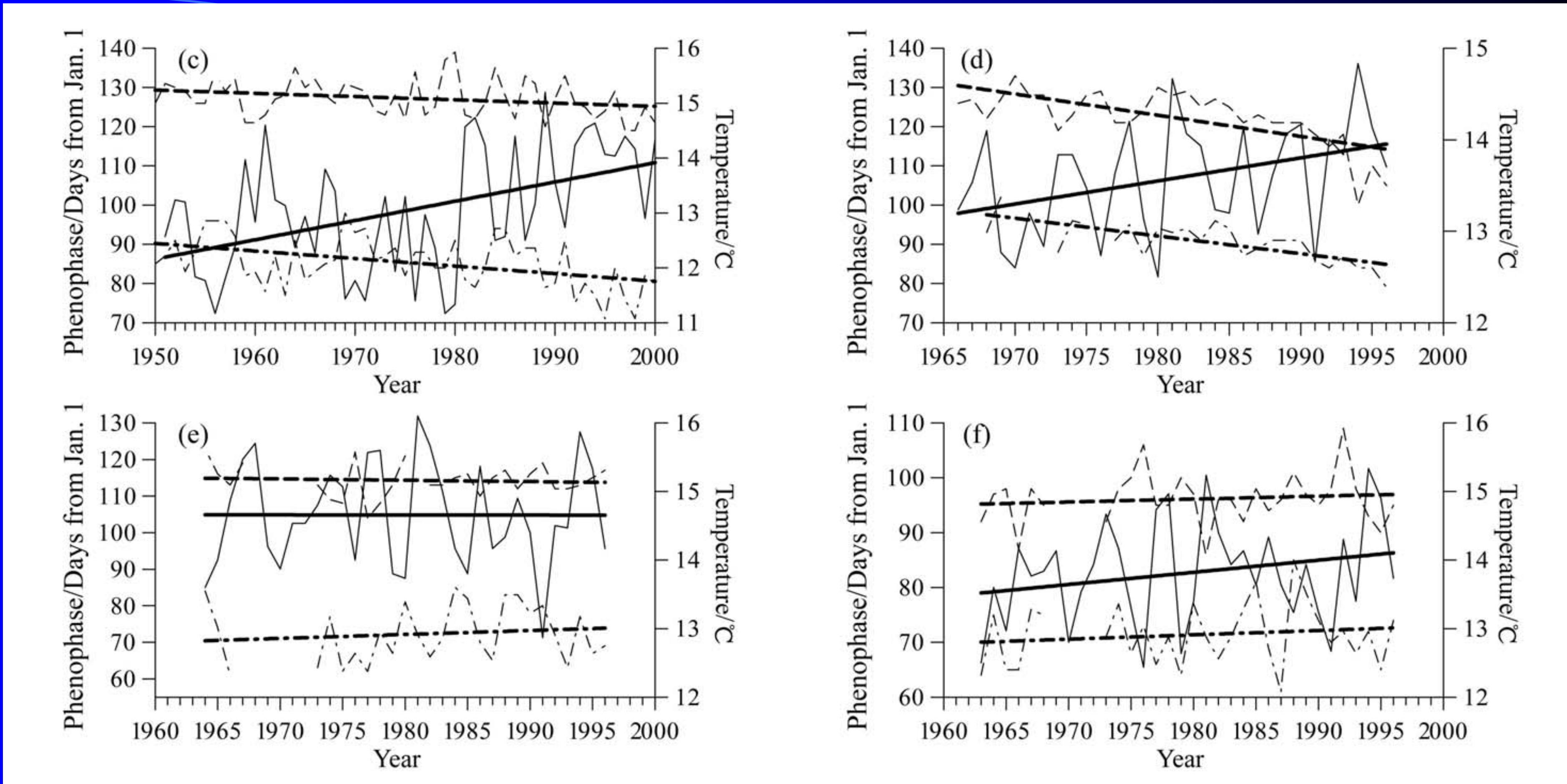


Figure The inter-annul phenophase and spring temperature variations for 10 stations

(a)Harbin, Dot-dash: *Betula mandshurica* N. leaf unfolding, Dash: *Syringa Oblata* Lindl flowering, Solid: temperature from April to May. Bold line: linear fitting.

(b) Shenyang, Dot-dash: *Ulmus pumila* L. Flowering in Shanhaiguan, Dash: *Syringa Oblata* Lindl flowering, Solid: temperature from April to May, Bold line: linear fitting.

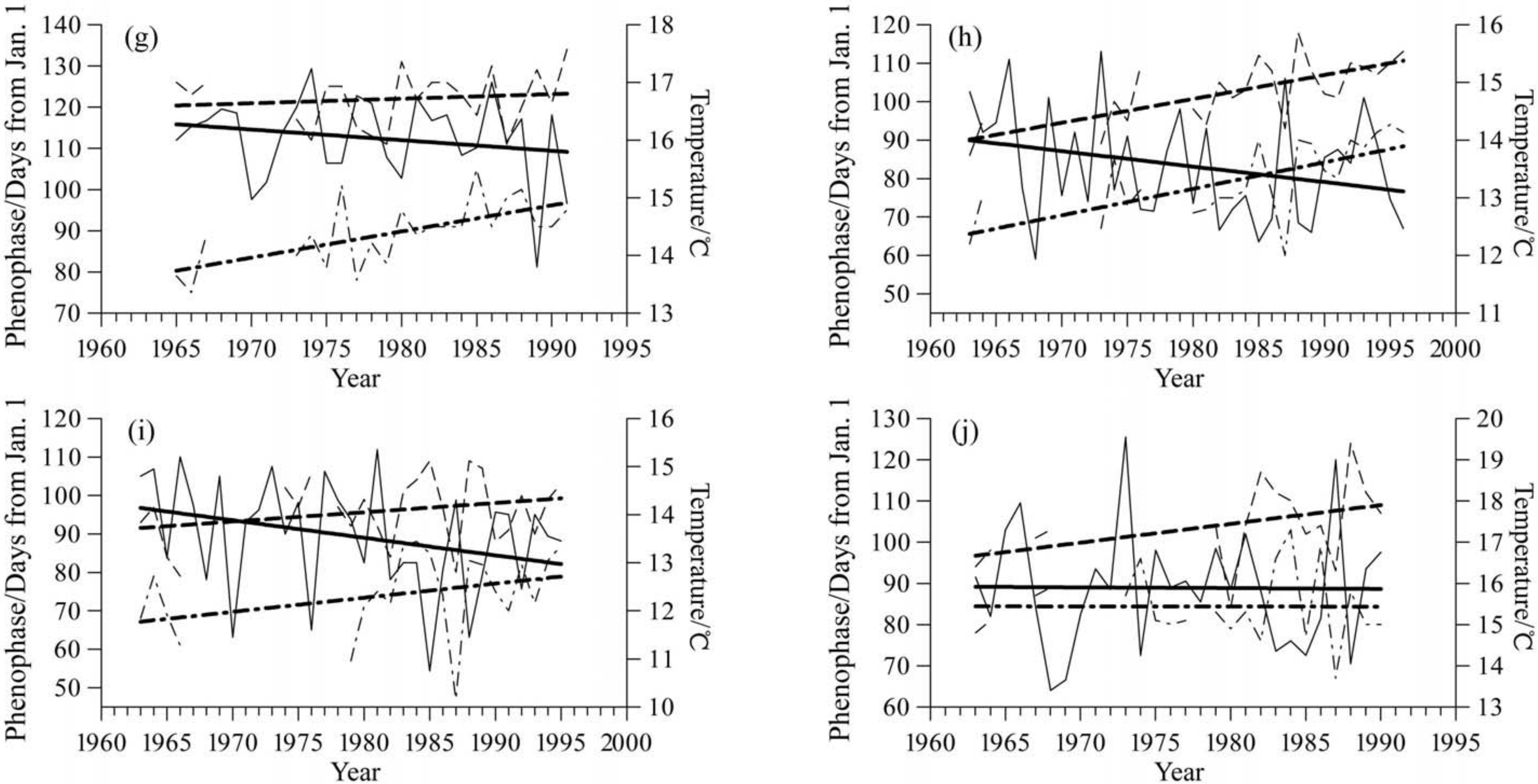


(c) Beijing, Dot-dash: *Prunus davidiana* Franch flowering, Dash: *Robinica pseudoacacia* L. blossom, Solid: temperature from March to May, Bold line: linear fitting.

(d)Yancheng, Jiangsu, Dot-dash: *Prunus persica* L. Batsch flowering, Dash: *Robinica pseudoacacia* L. flowering, Solid: temperature from March to May (Qingjiang, Jiangsu), Bold line: linear fitting.

(e) Luoyang, Dot-dash: *Salix babylonica* L. Leaf unfolding, Dash: *Robinica pseudoacacia* L. flowering, Solid: temperature from March to May (Zhengzhou), Bold line: linear fitting.

(f) Xi’an, Dot-dash: *Prunus davidiana* Franch flowering, Dash: *Syringa Oblata* Lindl flowering, Solid: temperature from March to May, Bold line: linear fitting.



(g) Changde, Hunan, Dot-dash: *Robinica pseudoacacia* L. leaf unfolding, Dash: *Melia azedarach* L. flowering, Solid: temperature from March to May, Bold line: linear fitting.

(h) Beibei, Chongqing, Dot-dash: *Cercis chinensis* Bge flowering, Dash: *Robinica pseudoacacia* L. flowering, Solid: temperature from Feb. to April (Shapingba, Chongqing), Bold line: linear fitting.

(i) Guiyang, Dot-dash: *Cercis chinensis* Bge flowering, Dash: *Firmiana simplex* W.F.Wight leaf unfolding, Solid: temperature from March to April.

(j) Guangzhou, Dot-dash: *Melia azedarach* L. flowering, Dash: *Gossampinus malabarica* (DC.) Merr leaf unfolding, Solid: temperature from Feb. to April.

2. Phenophase variation:

Inter-annual variation:

The inter-annual change of the spring phenophase is correspond to the spring temperature.

Trend:

Phenophase in spring advance in the northeastern, north of China and the lower reaches of Yangtze River;

No significant changing trend in the central of China, such as: Xi’an and Luoyan;

Phenophase in spring delay in the most part of the south of Qinling Mountain; including the east part of southwestern China and the middle reaches of Yangtze River.

Phenophase variation:

Spatial pattern

Fig The difference between the mean phenophase in spring for the period before the 1980s and that since the 1980s in China

(Dot: phenophase advance since 1981, Circle: phenophase delay since 1981)

3. Climate variation

3. Climate variation

Temperature

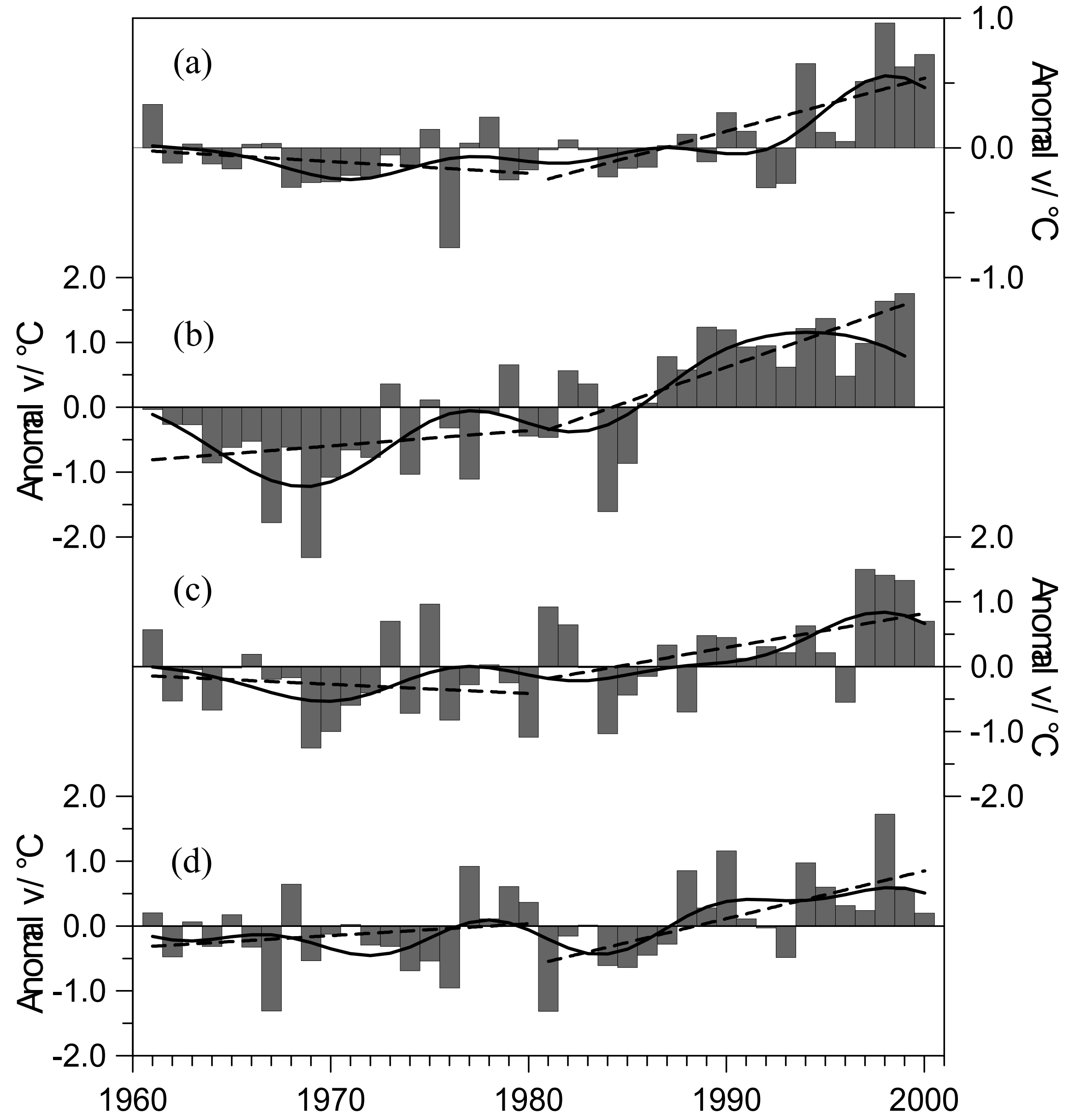


Fig Variations of temperature anomaly in China during 1961-2000

Bar: yearly series,

Solid line: 0.1Hz FFT Filter,

Dash line: linear fitting for

1961~1980 and

1981~2000 receptively

(a) growth season

(b) non-growth season

(c) transition season I

(d) transition season II

3. Climate variation

Temperature

Trend for the whole China average

Growth season: 1961~1980, a little cooling,

1981~2000, warming (0.41℃/10a)

Non-growth season: 1961~1980, a little warming

1981~2000, significantly warming (1.07℃/10a)

Transition season I: Similar with growth season, but with a high warming rate since 1981

Transition season II: Similar with non-growth season, but with a lower warming rate since 1981

3. Climate variation

Temperature

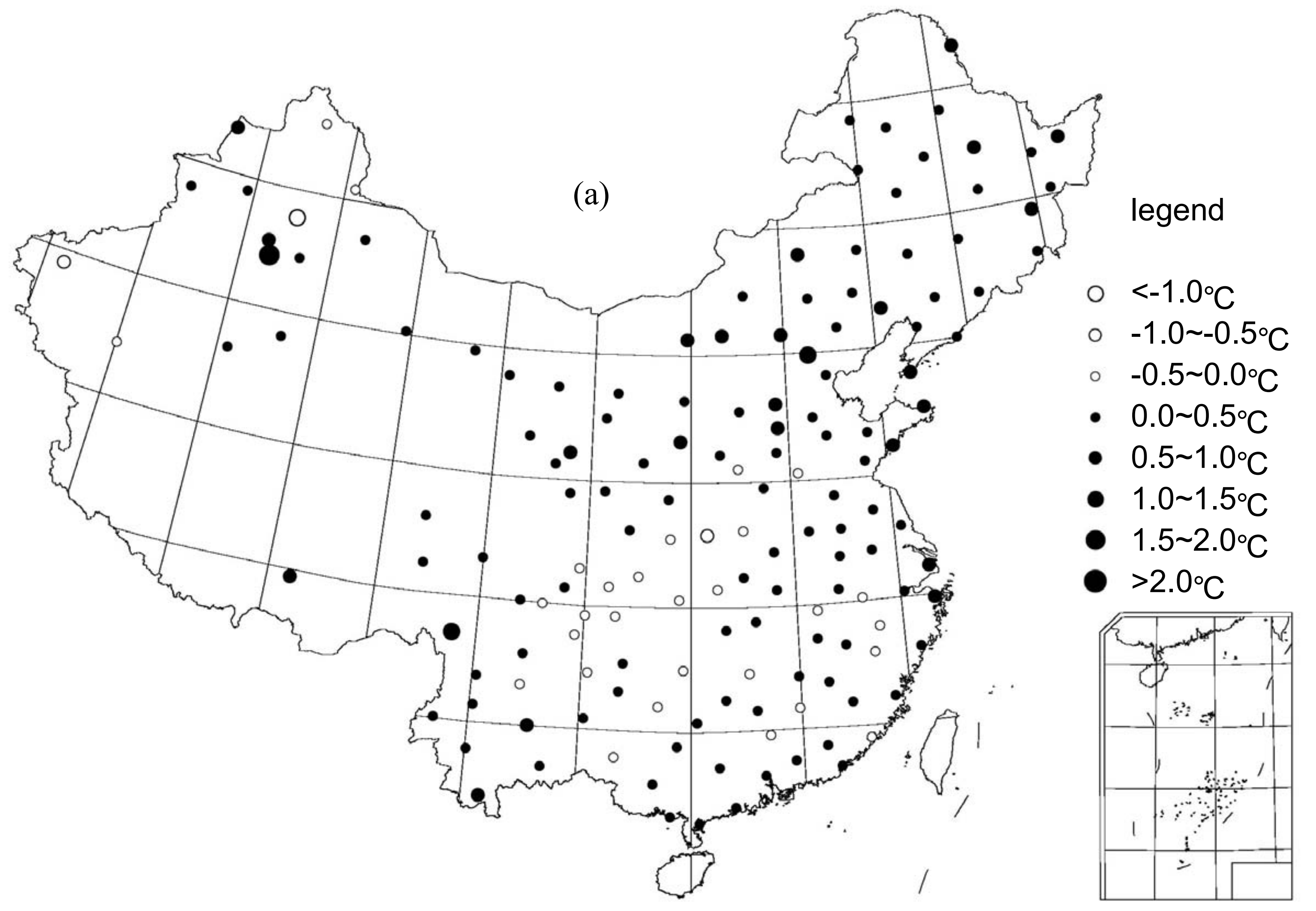


Fig. 2 The spatial distribution of the differences of the mean temperature in 1981~2000 and the mean temperature in 1961~1980
(a) growth season. Dot: Temperature increase, Circle: Temperature decrease

3. Climate variation

Temperature

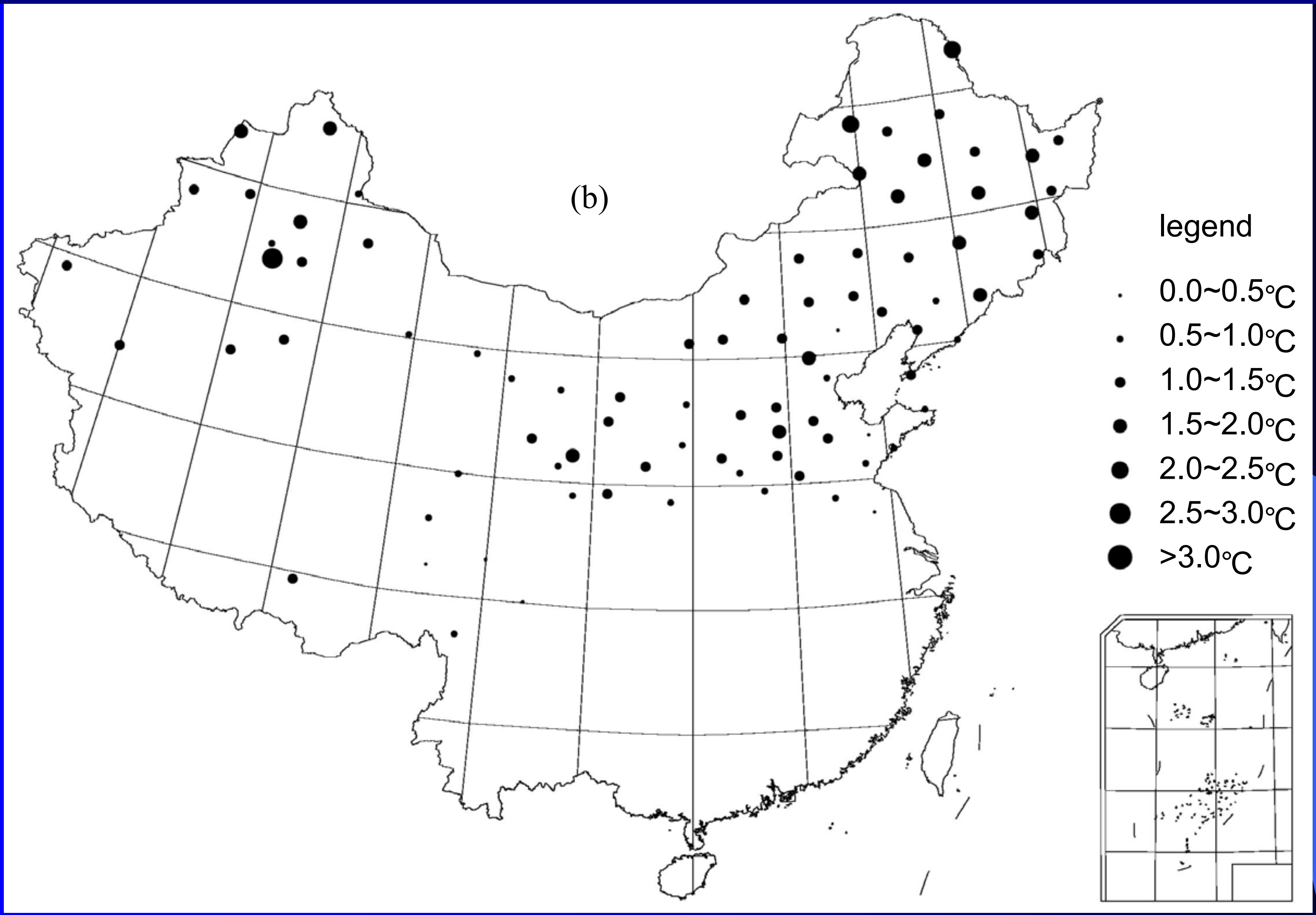


Fig. 2 The spatial distribution of the differences of the mean temperature in 1981~2000 and the mean temperature in 1961~1980

(b) non-growth season. Dot: Temperature increase, Circle: Temperature decrease

3. Climate variation

Temperature

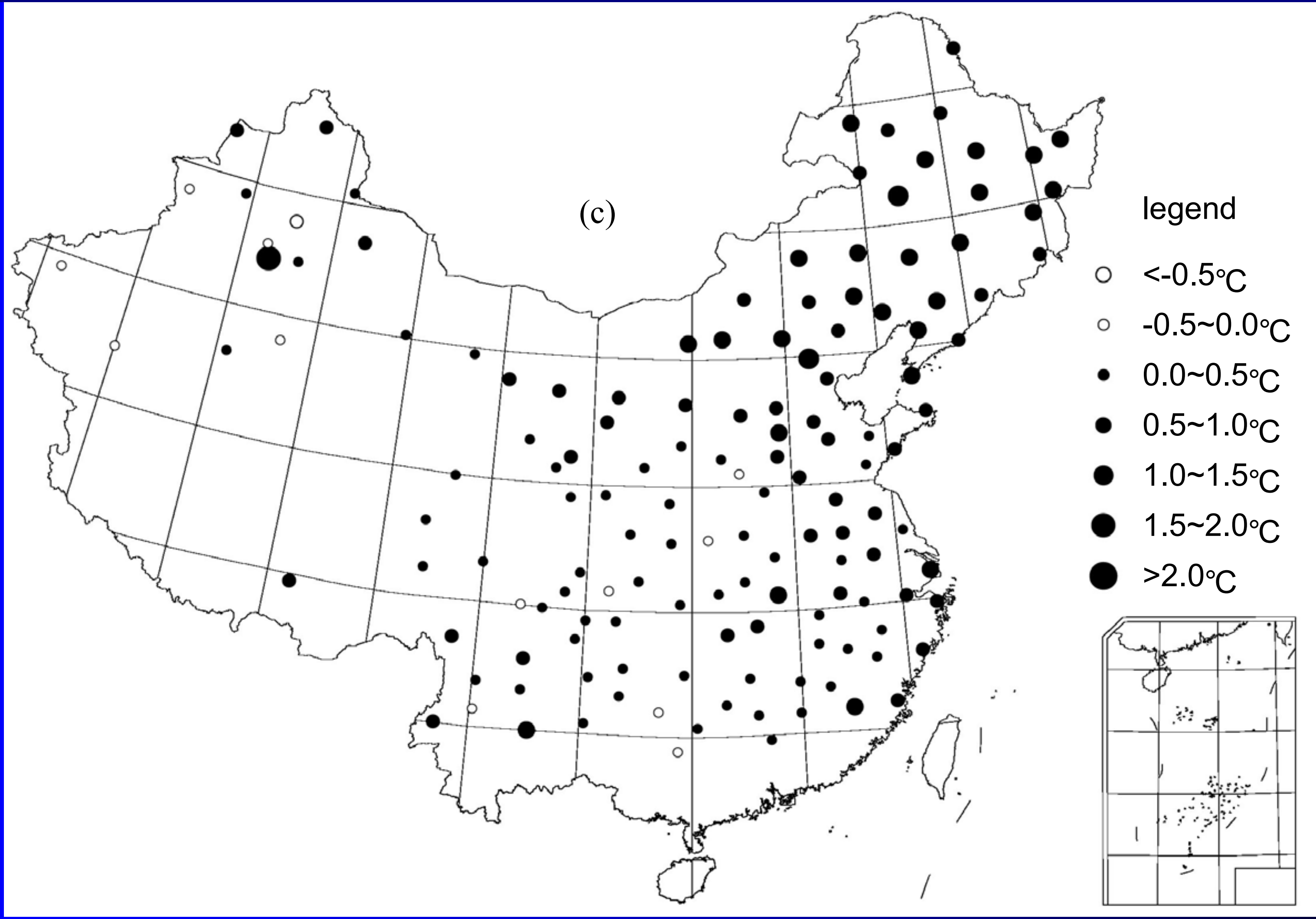


Fig. 2 The spatial distribution of the differences of the mean temperature in 1981~2000 and the mean temperature in 1961~1980

(c) transition season I. Dot: Temperature increase, Circle: Temperature decrease

3. Climate variation

Temperature

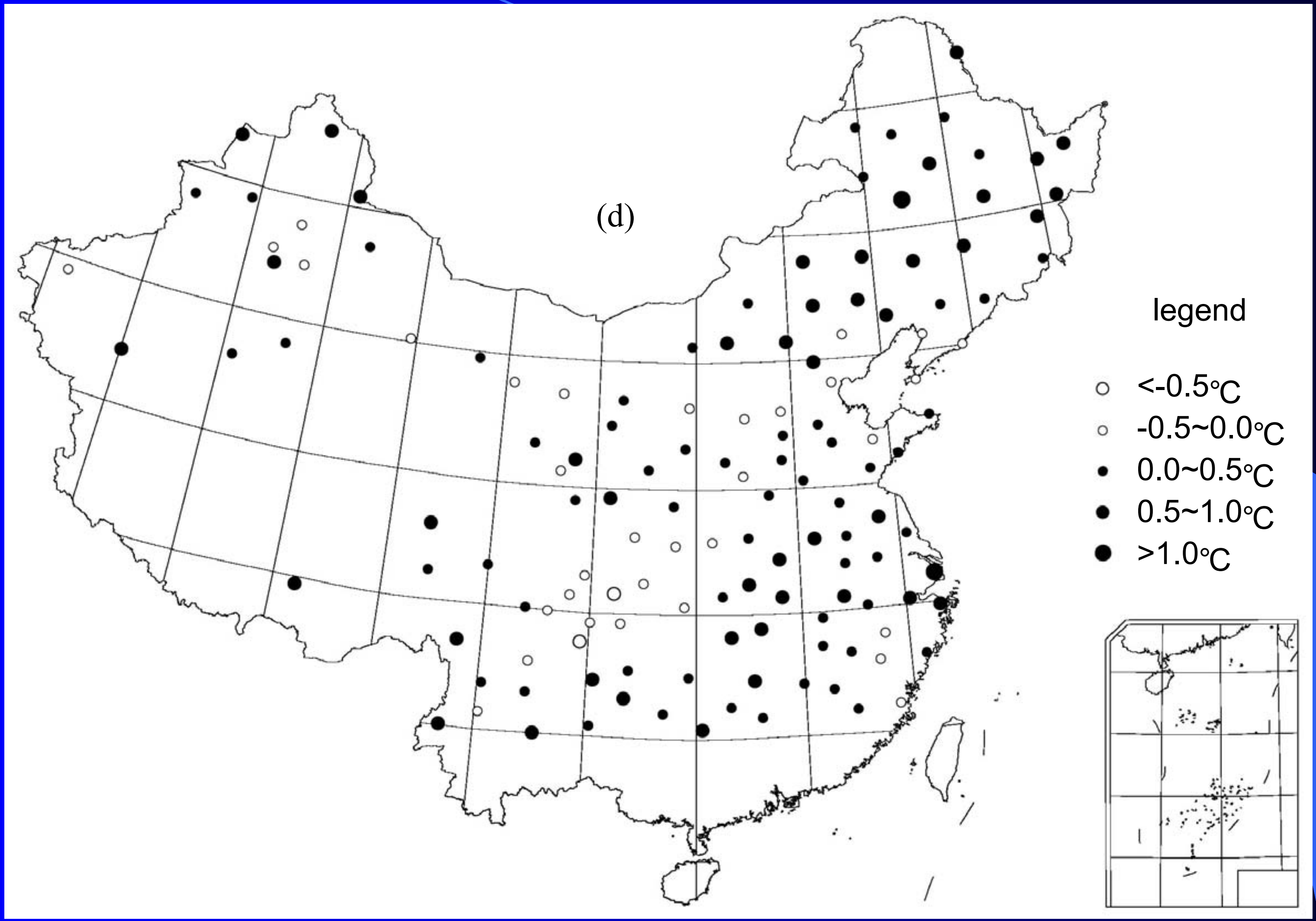


Fig. 2 The spatial distribution of the differences of the mean temperature in 1981~2000 and the mean temperature in 1961~1980

(d) transition season II. Dot: Temperature increase, Circle: Temperature decrease

3. Climate variation

Temperature

Spatial pattern:

Growth season: warming in most part of eastern China, southeastern of the Tibet Plateau and part of Xinjiang; cooling in the other part of Xinjiang and the most part of the south of Qinling Mountain; including the east part of southwestern China and the middle reaches of Yangtze River

Non-growth season: warming with a high rate in the northeastern, the lower reaches of the Yellow River and the north of Xinjiang

3. Climate variation

Spatial pattern:

Transition season I: warming in most part of China with highest warming rate in the northeastern and north of China, but cooling in some small part of Xinjiang and the south of Qinling Mountain;

Transition season II: warming in most part of China with highest warming rate in the northeastern of China, but cooling in most part of Sichuan.

3. Climate variation

Precipitation

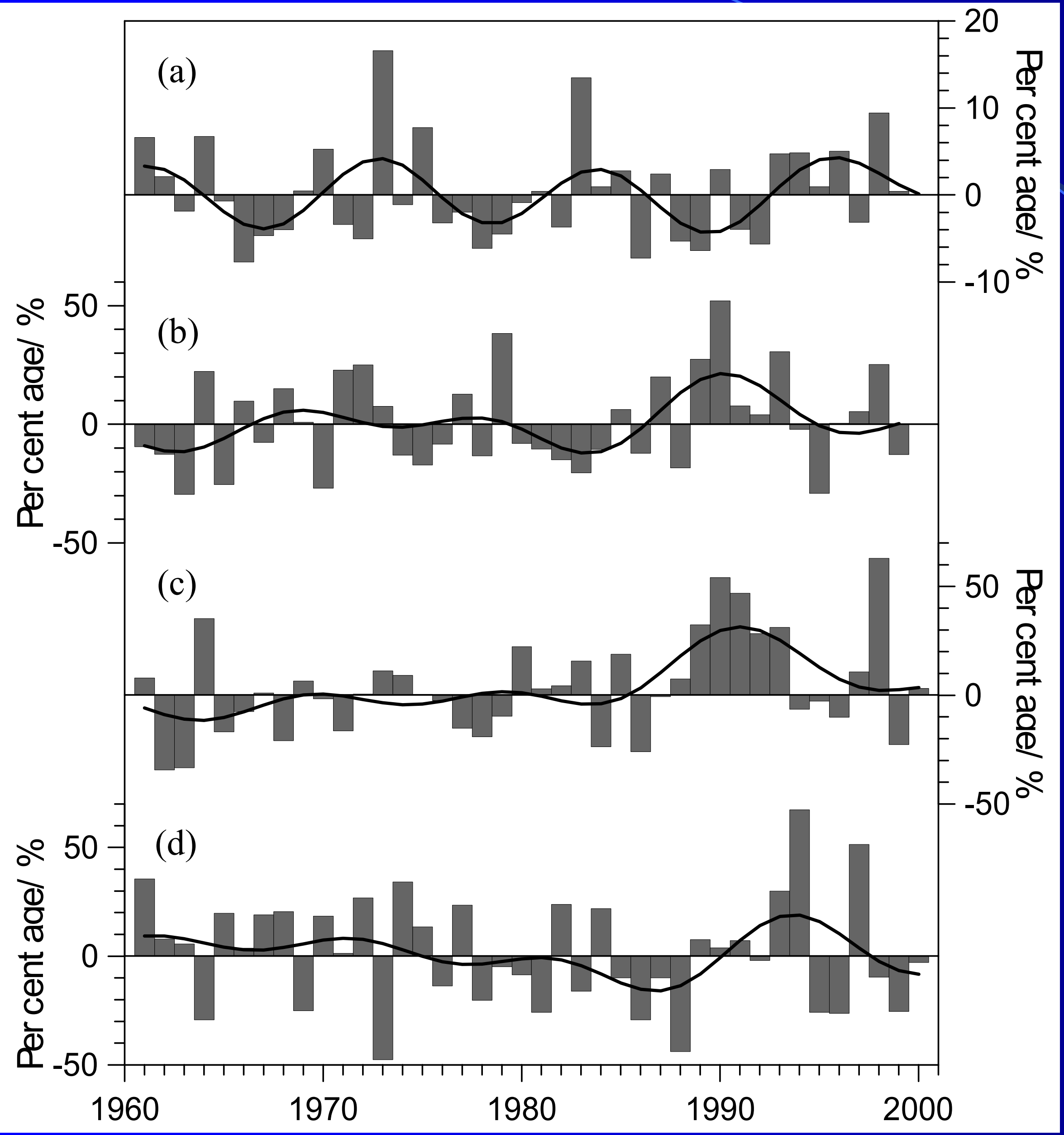


Fig Variations of precipitation anomaly percentage in China during 1961-2000

Bar: yearly series,

Solid line: 0.1Hz FFT Filter,

Dash line: linear fitting for

1961~1980 and

1981~2000 receptively

(a) growth season

(b) non-growth season

(c) transition season I

(d) transition season II

3. Climate variation

Trend for the whole China average

Growth season: inter-decadal variation, significant

rainy period: early of 1960s, 1970s, 1980s and mid-1990s

dry period: later of 1960s, 1970s, 1980s

Non-growth season: inter-decadal variation,

rainy period: later of 1960s, 1970s, 1980s

dry period: early of 1960s, 1970s, 1980s and mid-1990s

Transition season I: Similar with non-growth season

Transition season II: Similar with growth season

3. Climate variation

Precipitation

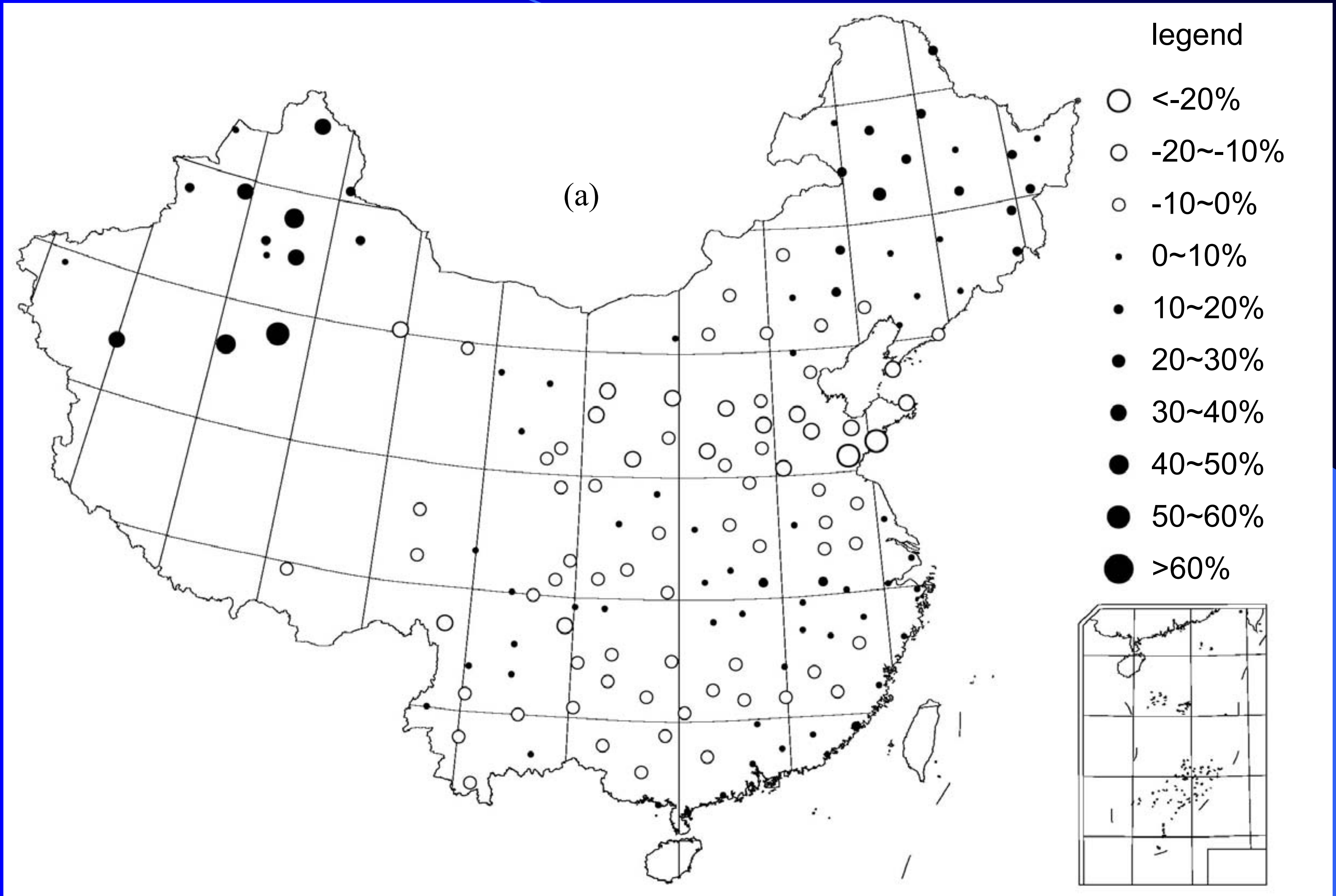


Fig. 4 The spatial distribution of the differences of the mean precipitation in 1981~2000 and the mean temperature in 1961~1980
(a) growth season. Dot: precipitation increase, Circle: precipitation decrease

3. Climate variation

Precipitation

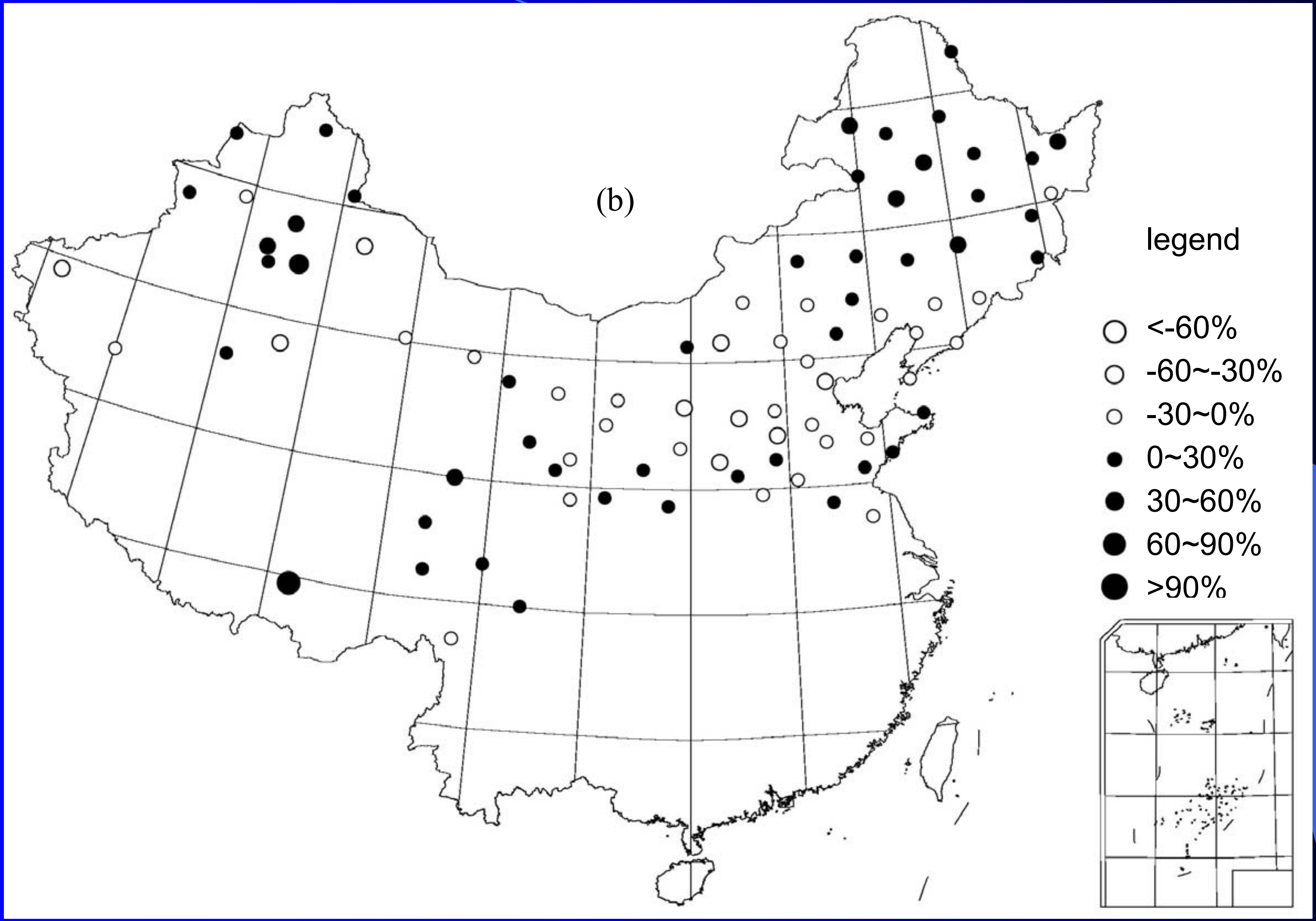


Fig. 4 The spatial distribution of the differences of the mean precipitation in 1981~2000 and the mean temperature in 1961~1980

(b) non-growth season. Dot: precipitation increase, Circle: precipitation decrease

3. Climate variation

Precipitation

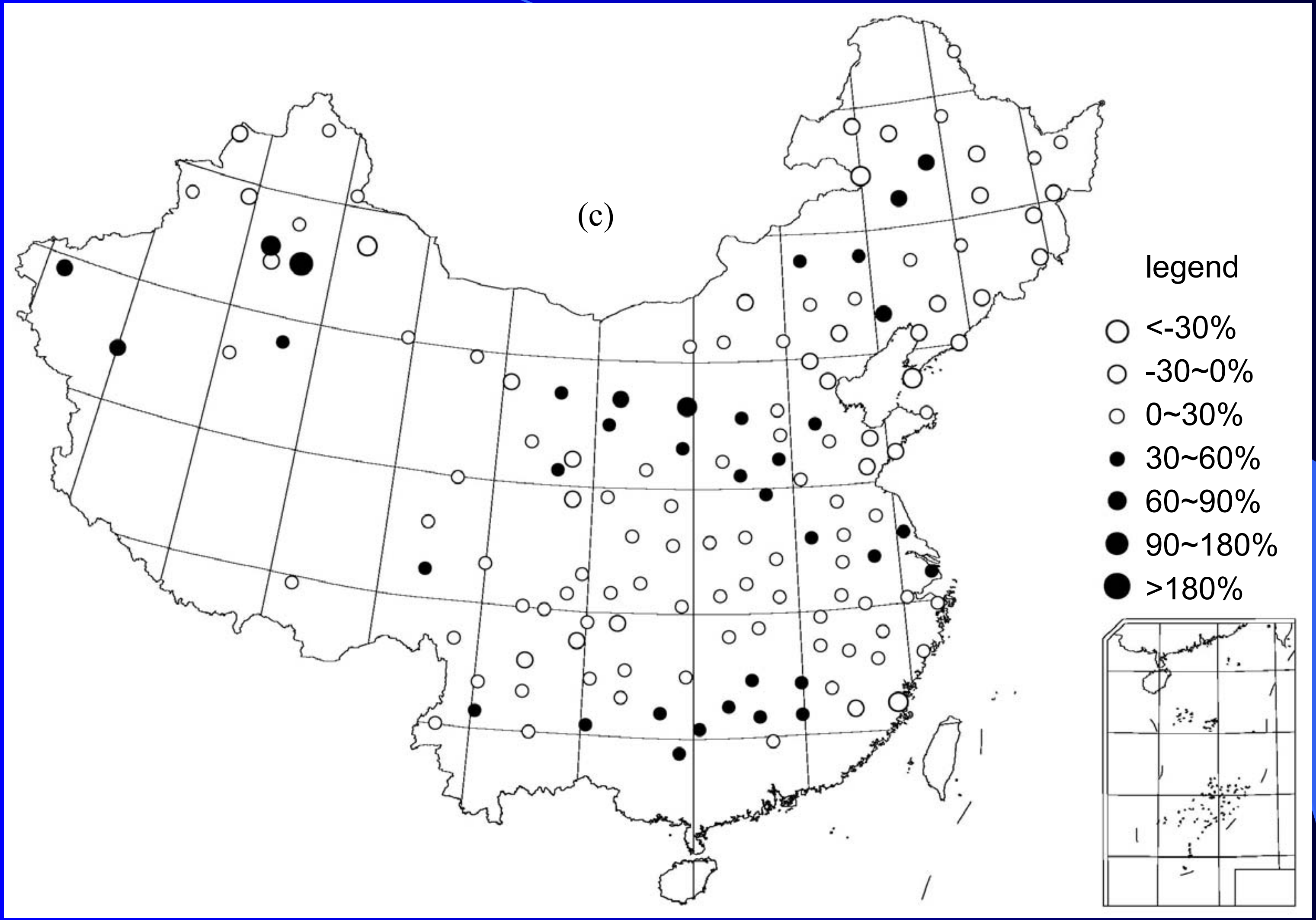


Fig. 4 The spatial distribution of the differences of the mean precipitation in 1981~2000 and the mean temperature in 1961~1980

(c) transition season I. Dot: precipitation increase, Circle: precipitation decrease

3. Climate variation

Precipitation

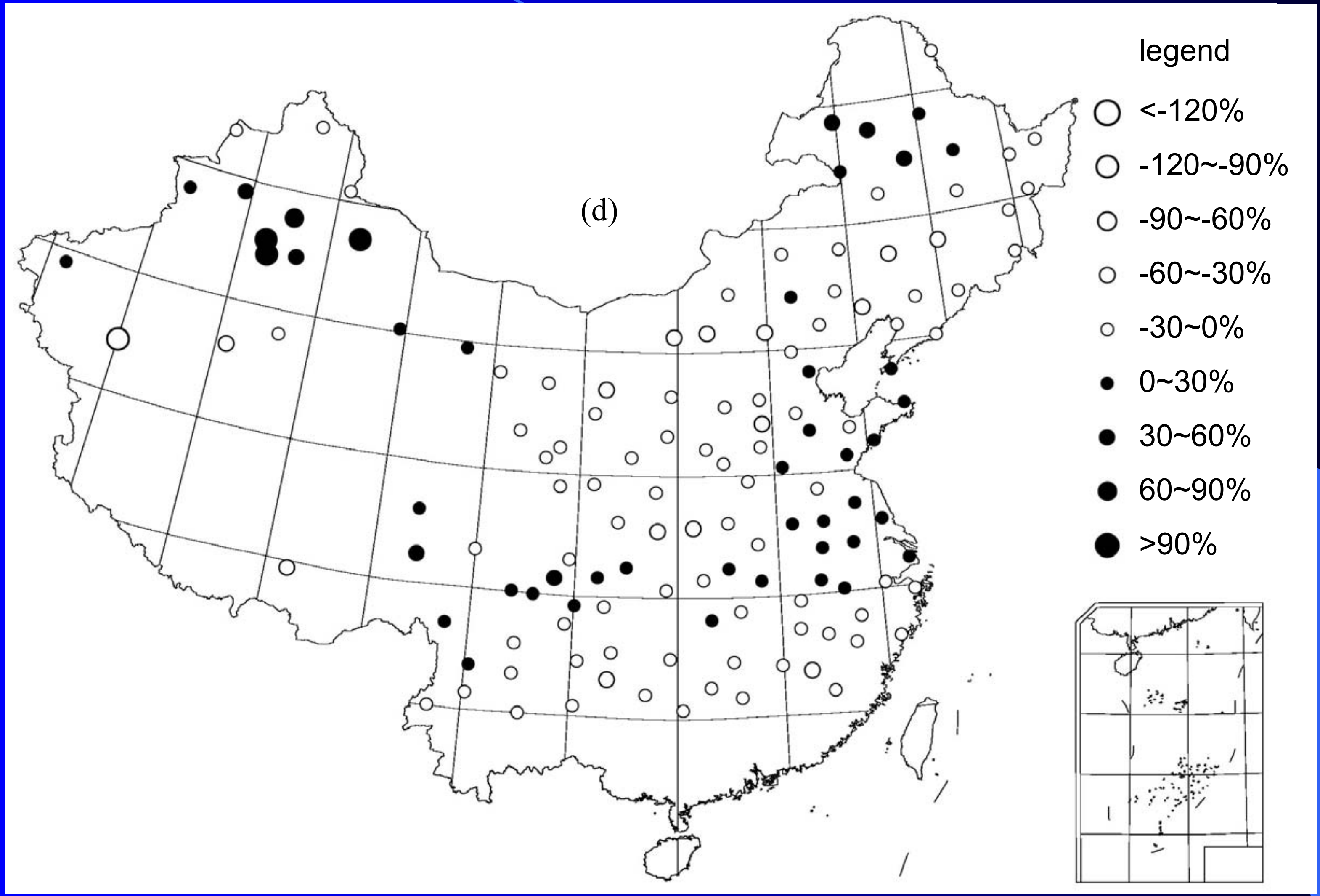


Fig. 4 The spatial distribution of the differences of the mean precipitation in 1981~2000 and the mean temperature in 1961~1980

(d) transition season II. Dot: precipitation increase, Circle: precipitation decrease

3. Climate variation

Spatial pattern:

Growth season: increase in most part of Xinjiang, northeast of China and the middle and lower reaches of Yangtze River; decrease in the other part of China with the highest rate in the north of China.

Non-growth season: increase in most part of northeast of China and Tibet Plateau; decrease in the north of China.

3. Climate variation

Precipitation

Spatial pattern:

Transition season I: decrease in most of China, expect for some part in the middle and lower reaches of Yellow River, the north of Nanling Mountain, and Xinjiang;

Transition season II: decrease in most of China, expect for some part in the west of northeast of China, middle part of Xinjiang, the upper reaches of Yangtze River, and the lower reaches of Yangtze and Huaihe River

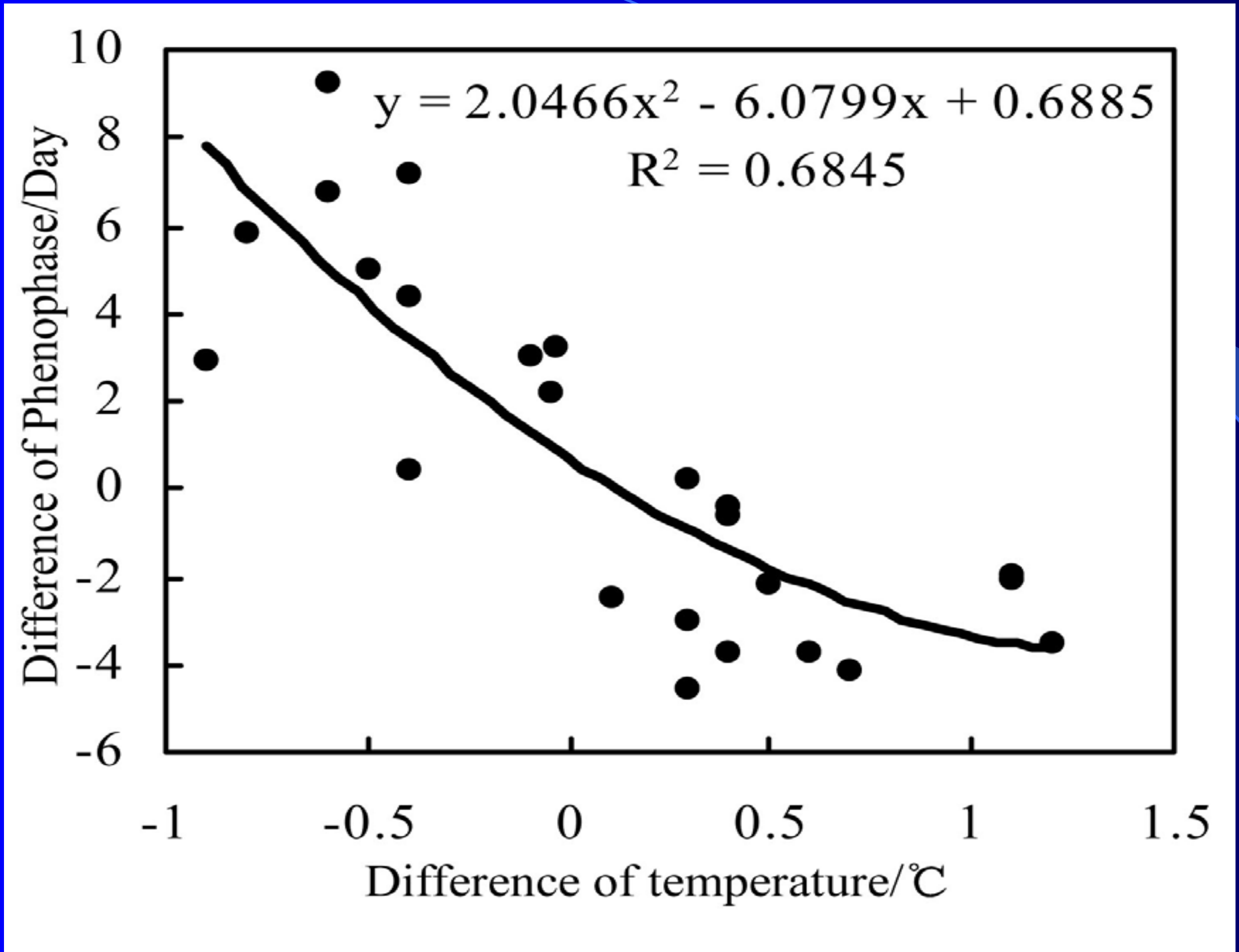
4. Relationship between phenophase and climate variations

4. Relationship

From the inter-annual variation for phenophase and temperature variation:

The inter-annual change of the spring phenophase is correspond to the spring temperature.

4. Relationship



The equation passed 0.001 significant level, and R^2=0.6845, means:

almost 70% variance could be explained

☞ **The diagram of the difference between the mean phenophase and temperature in spring for the period before the 1980s and that since the 1980s (Solid dot: observation, curve: polynomial fitting)**

4. Relationship

From the difference between the mean phenophase and temperature

☞ The relationship between temperature anomaly and phenology anomaly is significant, but the equation should be no-linear.

4. Relationship

☞ In the most of China, particularly in the eastern China

☆ The spring temperature increased by 0.5℃, the spring phenophase advanced by 2 days since the 1980s;

☆ The spring temperature increased by 1℃, the spring phenophase advanced by 3.5 days.

☆ However, the spring temperature decreased by 0.5℃, the spring phenophase delayed by 4 days;

☆ Spring temperature decreased by 1℃, the spring phenophase delayed by 8.8 days.

5. Summary

5. Summary

(1) On the average of the domain of China, warming began significantly since 1980 with a great warming rate for the non-growth season and a small warming rate for the growth season. Since 1980, the temperature of growth season increases in the most part of eastern China, the southeastern of Tibet Plateau and parts of Xinjiang province, in which the greatest variation is in the North China Plain. While, the temperature of growth season decreases in the most of south of Qinling Mountains, including the east of the Southwest and the middle reaches of Yangtze River, and the parts of Xinjiang province.

5. Summary

(2) In the growth season, there exist obvious inter-decadal variation for the precipitation of China during the last 40 years. But there were significant regional differences of the trends of the precipitation in growth season. Since 1980, the precipitation for growth season increases in Xinjiang province, Northeast China and the parts of the lower and middle reaches of the Yangtze River, while the precipitation for growth season decreases in the other areas in China, in which the greatest variation is in the North China Plain.

5. Summary

(3) Since the 1980s, the plant phenophases in spring advanced obviously in the Northeast and Northwest of China, the North China Plain, the lower reaches of the Yangtze River and the south of Yunnan Province. While, the phenophases in spring delayed in the east part of the Southwest of China and the middle reaches of the Yangtze River. The variation pattern of plant phenophases is corresponding to the temperature variation pattern of the growth season in China.

End of this presentation

Thank you

Thank you